

TRB Webinar: State and Local Government Responses to Climate Change



Today's Presenters and Moderator



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Today's Presenters and Moderator

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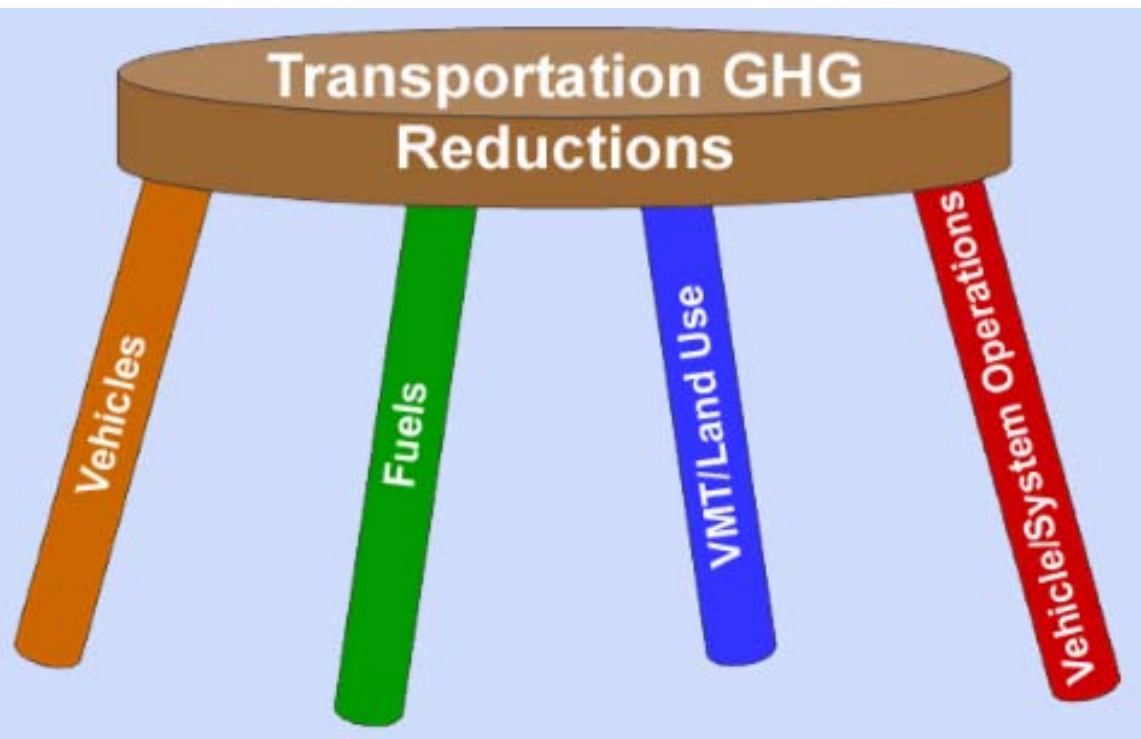


Climate Change and Transportation Planning

TRB Webinar
October 6, 2009



What can be done to reduce Greenhouse Gases? Multiple Transportation Strategies



- Raise vehicle energy efficiency
- Reduce carbon content of fuels
- Reduce VMT
Land use
- Improve system and operational efficiencies



“Two Legs of the Stool”



Transportation System Efficiencies

- **Traffic flow improvements**
 - ITS/Management and Operations
 - Improved Intermodal connections



Travel (by SOV) Activity Reduction

- **Reducing VMT**
 - Land Use strategies
 - Bike/ped
 - Transit
 - Pricing



Planning Factors



- Accessibility and mobility
- Protect and enhance the environment
- Safety
- Security
- Promote energy conservation
- Improve quality of life
- Promote consistency between transportation and planned growth and economic development
- Efficient system management and operation
- Preservation of existing system

Transportation Plan



- Integrated multimodal system
- Transit, multimodal & intermodal, pedestrian walkways & bike facilities
- Operational and management strategies
- Environmental mitigation
- Consultation



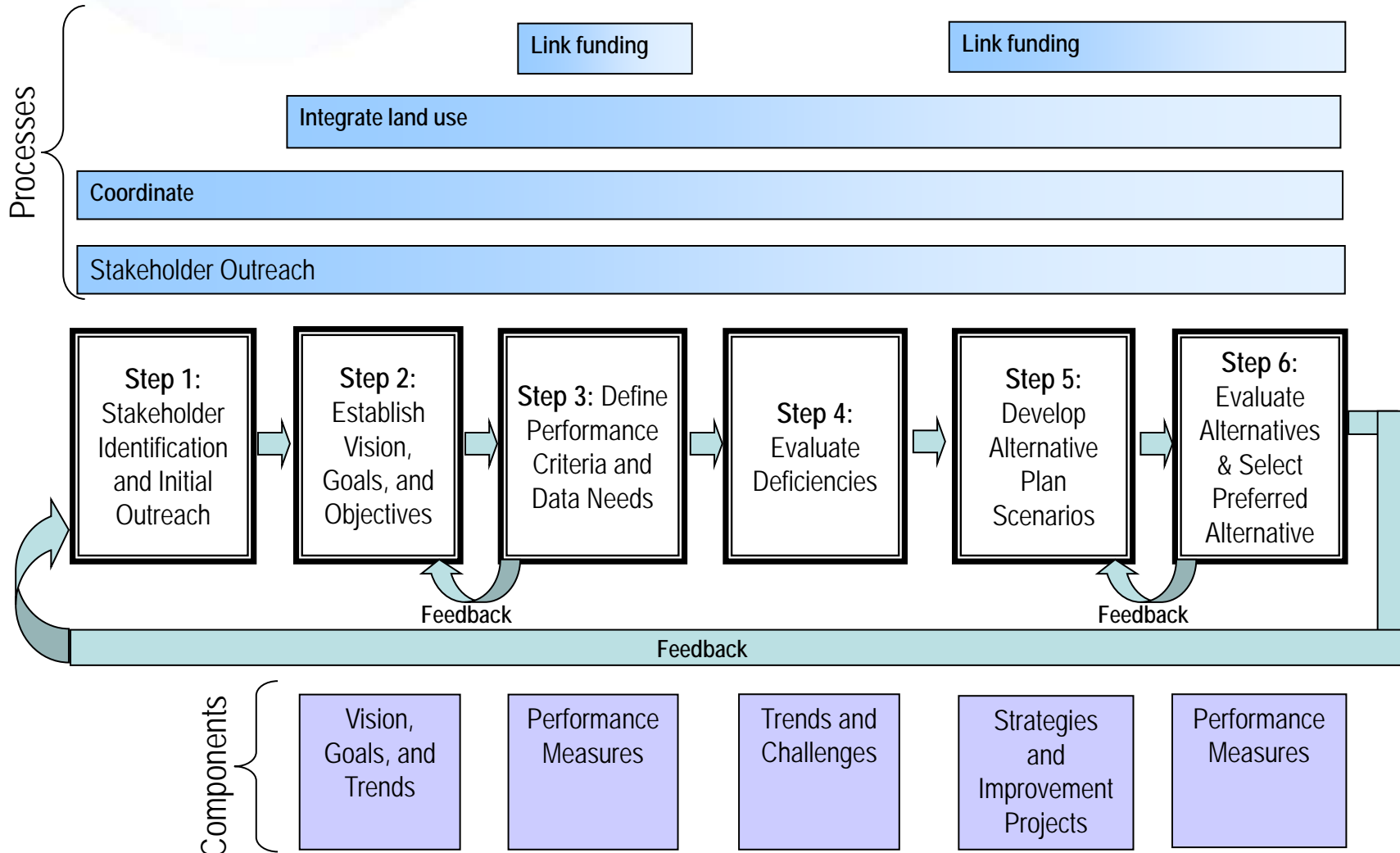
Federal Highway Administration
Integrating Climate Change into the
Transportation Planning Process

Final Report

July 2008

<http://www.fhwa.dot.gov/hep/climatechange/index.htm>

Climate Change in Planning



Overview of Current Practice



- **Acknowledge connection between transportation and climate change**
- **Mitigation of GHG emissions**
 - **(vision – goals – policies – strategies)**
- **Performance measures**
 - **Related to GHG emissions**
- **Quantifying GHG emission**
 - **Emerging: tools, methods, data**

Climate Change in Current Statewide Plans

DOT	Status of LRTP	Trends & Challenges	Vision & Goals	Policies & Strategies	Performance Measures
Maine	adopted 2007	■	■	■	
New Mexico	adopted 2005				
Arizona	adopted 2004				
Colorado	adopted 2008	■			
Connecticut	adopted 2004	■	■	■	
Massachusetts	adopted 2006			■	
Maryland	draft goals 2008				
Oregon	adopted 2006	■	■	■	
Washington	adopted 2006	■			
California	adopted 2006	■	■	■	
Florida	adopted 2005		■		
New York	adopted 2006			■	

■ Climate change mitigation

■ Climate change mitigation & adaptation

Source: ICF International, *Integrating Climate Change Considerations into the Transportation Planning Process*. Prepared for Federal Highway Administration, July 2008. Available at: <http://www.fhwa.dot.gov/hep/climatechange/climatechange.pdf>

Climate Change in Current RTPs

MPO Region	Status of LRTP	Trends & Challenges	Vision & Goals	Policies & Strategies	Performance Measures
Albany, NY	draft August 2007			■	
Baltimore	adopted Nov 2007	■		■	
Chicago	updated June 2007		■		
Denver	adopted Dec 2007				
Eugene, OR	final draft Sep 2007			■	
Grand Rapids, MI	adopted April 2007	■			
Houston-Galveston	updated Oct 2007	■			
Missoula, MT	adopted May 2004		■		
Philadelphia	adopted 2005				
Portland, OR	final draft Jan 2008	■	■	■	■
Sacramento	draft Nov 2007	■		■	
Salt Lake City	adopted May 2007				
San Diego	adopted Nov 2007	■	■	■	
San Francisco	draft goals 2008		■		■
Santa Fe, NM	draft due 2009				
Seattle	adopted Spring 2008**	■	■	■	■
Southern California	adopted May 2008	■			■
Washington, DC	adopted Oct 2006				

- Climate Change Mitigation
- Climate Change Mitigation & Adaptation

Source: ICF International, *Integrating Climate Change Considerations into the Transportation Planning Process*. Prepared for Federal Highway Administration, July 2008. Available at: <http://www.fhwa.dot.gov/hep/climatechange/climatechange.pdf>

** Refers to Vision 2040, a regional growth, transportation, and economic strategy.



Integration of Climate Change Considerations in Statewide and Regional Transportation Planning



Final Report July 2009



http://climate.dot.gov/state-local/integration/planning_process.html

Integration of Climate Change Considerations in Statewide and Regional Transportation Planning



➤ Case Studies and Proceedings

- TRB Panel
- AMPO Conference

➤ Climate Change in Transportation Planning

- Vision and long range planning
- Forecasts, data and performance measures
- Public involvement
- Collaboration with partners
- Project selection



Example Strategies



➤ Mitigation Strategies

- Alternative vehicle and fuel technologies
- More efficient land use patterns
- Increase use of transit, freight rail, bicycling, walking
- Limit use of GHG emitting construction materials
- Increase investment in non-motorized transportation
- Low-GHG fuel
- Tailpipe emission standards
- Slow VMT growth
- Increase low-GHG travel choices
- Shift freight from highways to rail and marine modes



Example Strategies, continued



➤ Mitigation Strategies

- Congestion relief
 - Public transit
 - Coordination of transportation/land use
 - Pay as you drive insurance
 - Congestion pricing
 - Anti-idling measures
 - Operations
 - Eco-driving
 - Commute travel reduction
 - Highway operations and management
-
- Recognize Existing Strategies that reduce GHG





What is Adaptation?

Actions to avoid, withstand, or take advantage of climate changes and impacts

- **Adapting transportation assets to the new and emerging effects of climate change**
- **Magnitude difficult to assess**
- **Potential implications for where we locate and how we build**

Adaptation Options



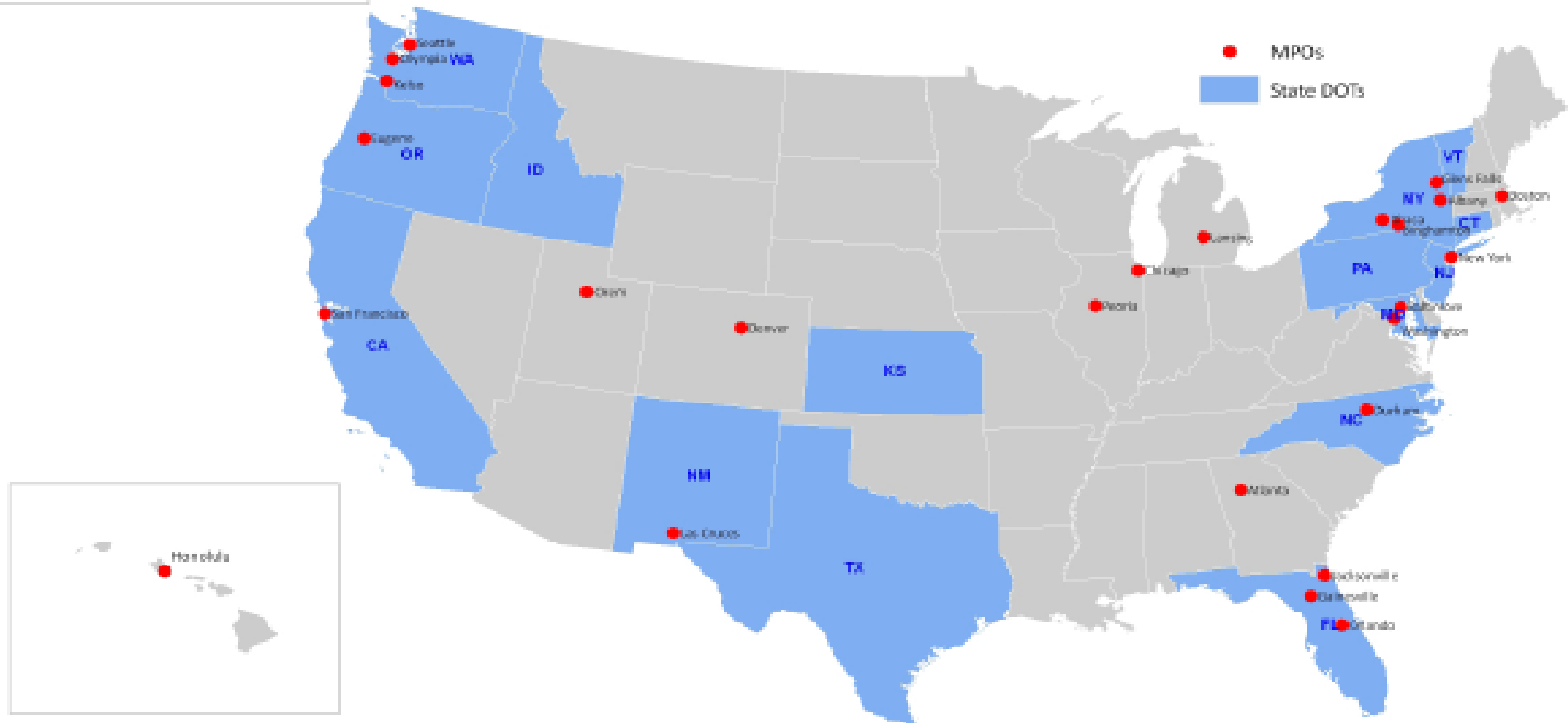
- **Maintain and manage**
 - Higher maintenance costs
- **Protect, strengthen**
 - Sea walls and buffers
 - Design changes when rebuilding
- **Relocate**
 - Move key facilities, site new facilities in less vulnerable locations
- **Abandon and Disinvest**
- **Enhance redundancy**



FHWA Peer Exchanges



DOT and MPO Participation in FHWA Climate Change & Transportation Peer Workshops During 2008



What Are We in FHWA doing? (Mitigation)



- Working with stakeholders to develop effective policy approaches for reducing the growth in VMT
- Assessing and analyzing the most cost-effective mitigation strategies and the reductions associated with “bundling” those strategies
- Playing key roles in the Secretary’s Livability Initiative and the HUD-DOT-EPA Sustainable Communities Partnership
- Offering technical assistance to State DOTs and MPOs in an effort to update existing models and provide training on MOVES
- Carbon sequestration pilot program



What Are We in FHWA doing? (Adaptation)



- **Developing strategy to address adaptation to climate change effects**
- **Interim framework on conducting assessments of transportation infrastructure vulnerable to global climate change effects**
 - Implementation Pilots for Framework
- **Guidelines for consideration of global climate change impacts and adaptation in project development and environmental review**
- **Coordination activities with NOAA/NWS**
- **Peer exchanges**





For More Information:

Federal Highway Administration Climate Change Website:

<http://www.fhwa.dot.gov/hep/climate/index.htm>

US DOT Transportation and Climate Change
Clearinghouse:

<http://climate.dot.gov/index.html>



Climate Change Strategies for the Mobile Sector in the Metropolitan Washington Region

Presentation for TRB Webinar:
State and Local Government Responses to Climate Change

October 6, 2009

Ronald Kirby

Director, Department of Transportation Planning

National Capital Region Transportation Planning Board (TPB)

Metropolitan Washington Council of Governments (COG)

Transportation Planning in the Washington Region

TPB is the Metropolitan Planning Organization (MPO) and is housed within the Metropolitan Washington Council of Governments (COG)

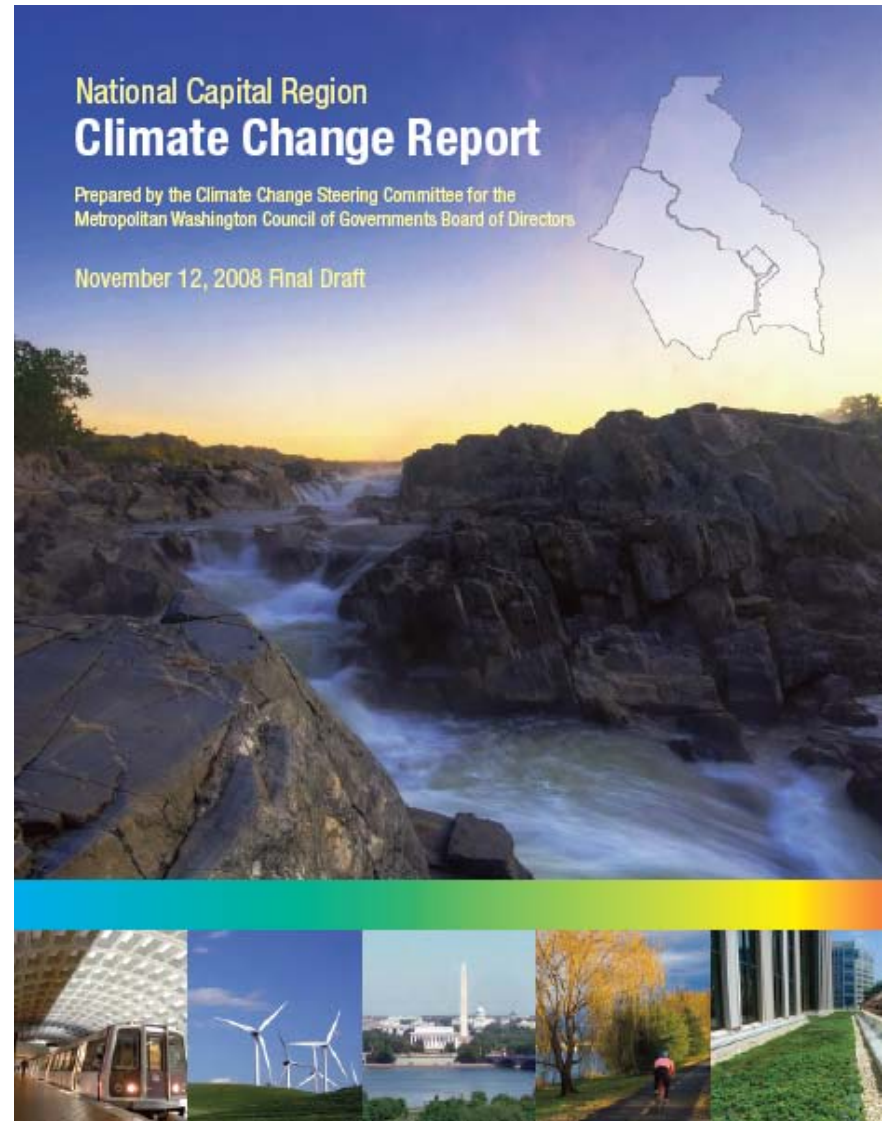


COG Climate Change Report

November 12, 2008

Regional GHG
reduction goals

Recommendations for
the mobile sector



COG Regional Goals

“Consistent with the climate science and the goals adopted by the state and local governments in the Washington region”

Return to 2005 levels by 2012

20% below 2005 levels by 2020

80% below 2005 levels by 2050

TPB is applying these goals to the transportation sector:

What would it take to meet these goals in transportation?

How is TPB Addressing Climate Change?

- Developed baseline GHG projections for transportation through 2030
 - Updated for new CAFE standards and changing regional vehicle fleet
- Conducting a regional scenario study:
 - Using COG goals, analyzing a “What Would It Take?” Scenario for GHG reduction, including fuel efficiency, alternative fuels, travel efficiency
 - Analyzing a “Constrained Long Range Plan (CLRP) Aspirations” Scenario to examine the effects of pricing, more transit and transit-oriented land use development
- Seeking GHG reduction strategies that could be included in the region’s transportation plans and programs

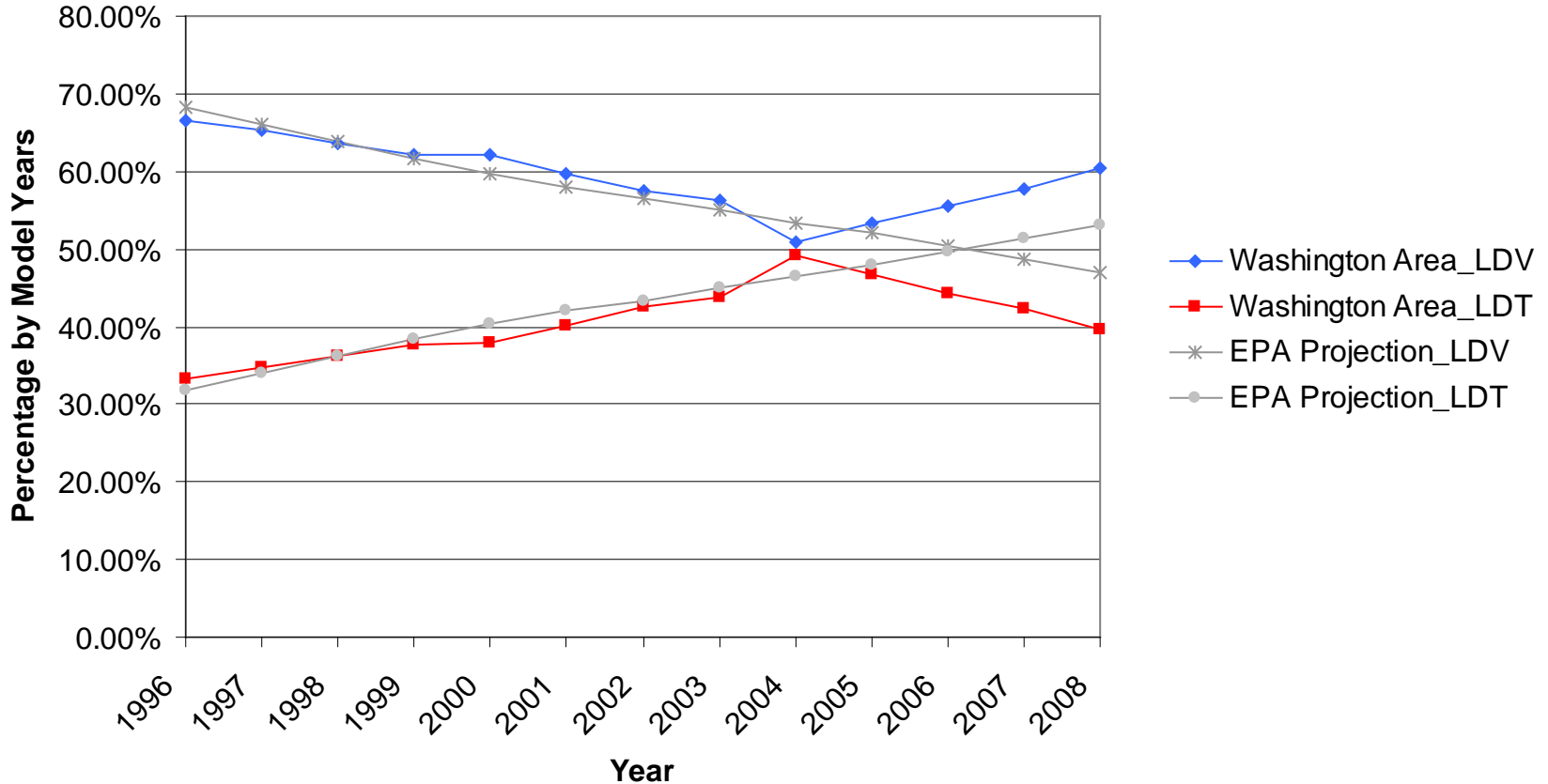
Setting the Baseline

CO₂ Emissions from Cars, Trucks, and Buses Annual MT of CO₂ Emissions 8-hour Ozone Non-Attainment Area

	2005	2020	2030
BAU (prior to new CAFE standards)	24.1	29.9	32.3
% Change from 2005 levels	---	24.2%	34.0%
+ 2009 CAFE (35.5 mpg by 2016)	24.1	24.1	23.4
% Change from 2005 levels	---	0%	-3%
+ Committed TERMS (final baseline)	24.1	23.9	23.3
% Change from 2005 levels	---	-1%	-3%
CCSC Proposed Regional Goal	24.1	19.3	14.5
% Change from 2005 levels	---	-20.0%	-40%
What's Left to Meet the Goal?	---	4.6	8.8
% Change from 2005 levels	---	-19%	-37%

Setting the Baseline: The fleet is changing

Washington Area Passenger Vehicles (LDV) and Light Duty Trucks (LDT) Percentages of Total Light Duty Vehicles by Model Year



Setting the Baseline:

External Factors are Affecting Regional Emissions

New Conformity Analysis (2009) vs. Previous (2008):

Factors tending to reduce emissions:

- More hybrids
- Shift away from SUV's to passenger cars
- Less VMT

Factors tending to increase emissions:

- Fewer new vehicles being purchased

Net: emissions significantly higher (+6.6% VOC, +7.5% NOX)

- 'Older vehicle fleet' more than offsets more hybrids, shift away from SUVs to passenger cars, and less VMT

Example Mobile GHG Reduction Strategies Being Examined

Fuel Efficiency

- Extending CAFE requirements to heavy trucks (8% VMT, 20% GHG)
- Cash for Clunkers programs
- Benefits of enhanced CAFE possibilities (eg 45/55 mpg by 2030)

Alternative Fuels

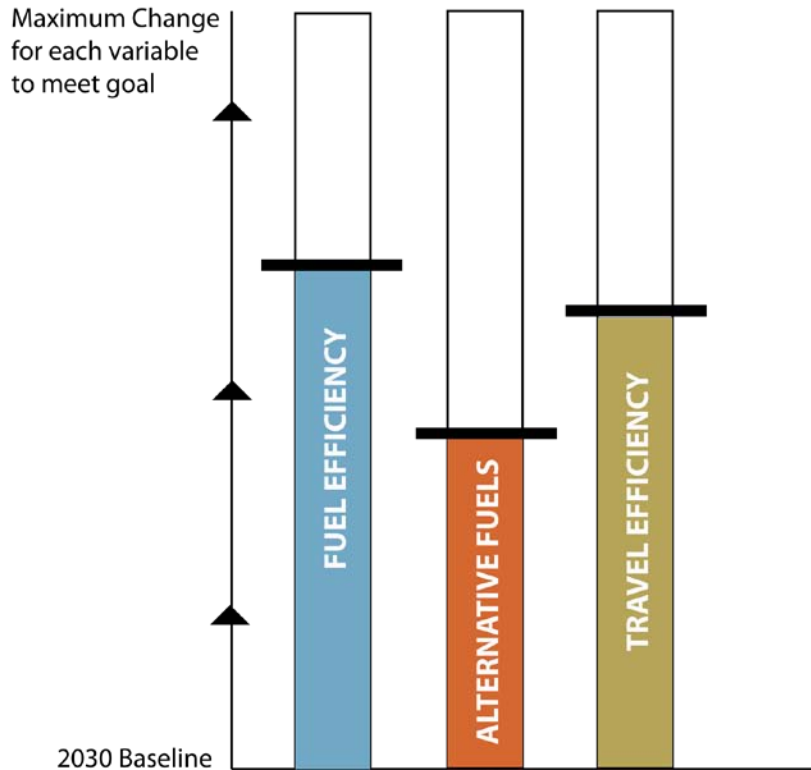
- Regional green fleet policy
- Accelerated adoption of clean-fuel vehicles (hybrids, flex fuel)

Travel Efficiency:

- Pricing policies to reduce VMT (tolling, congestion pricing, parking pricing)
- Shift short trips to non-motorized modes
- Increased transit capacity
- Land use shifts (TOD, walkable activity centers)
- Signal optimization (operating speeds matter)

Putting the Strategies Together

“Sliders” metaphor

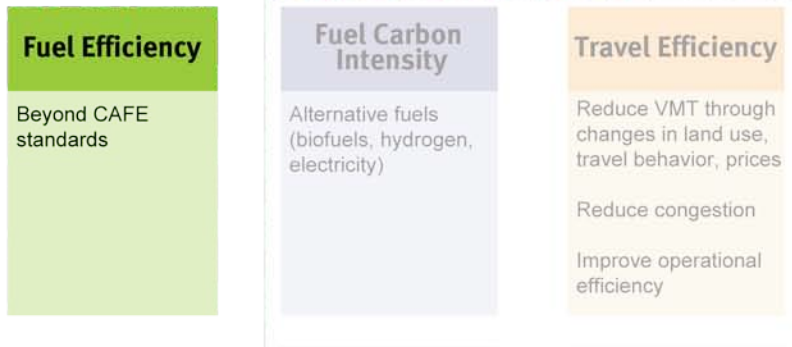


How can strategies across these categories be combined to meet our regional climate change goals?

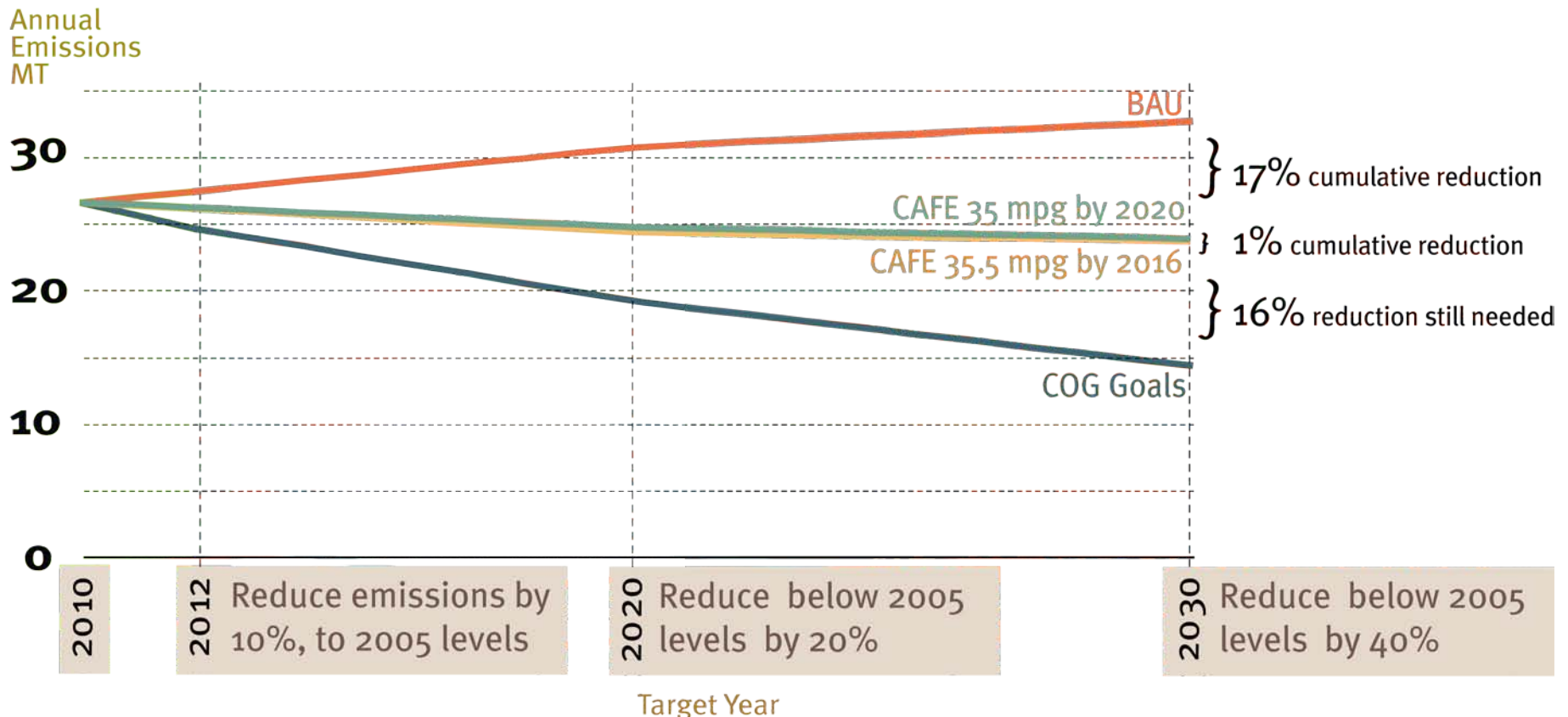
There can be compound effects from “bundling” strategies, such as transit and land use.

Achieving the Goal

40% reduction in mobile CO₂ emissions below 2005 levels by 2030



Fuel Efficiency CAFE Standards

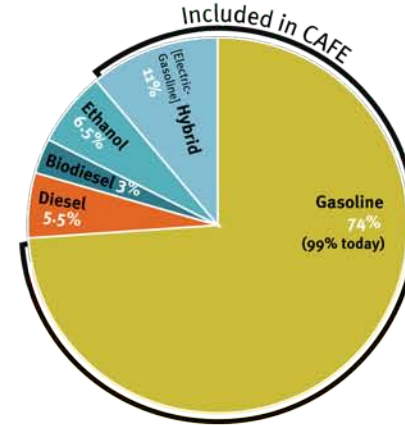


Achieving the Goal

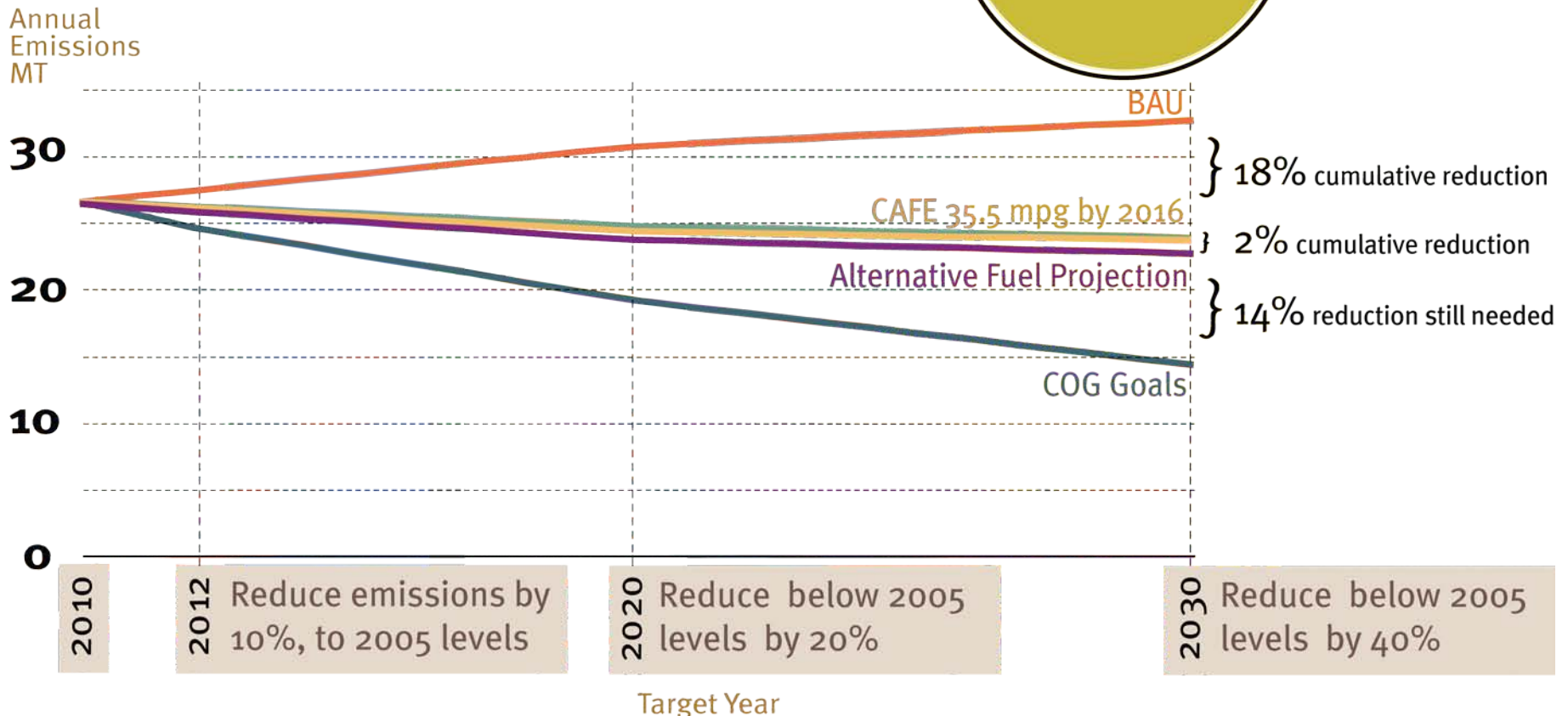
40% reduction in mobile CO₂ emissions below 2005 levels by 2030

Fuel Efficiency Beyond CAFE standards	Fuel Carbon Intensity Alternative fuels (biofuels, hydrogen, electricity)	Travel Efficiency Reduce VMT through changes in land use, travel behavior, prices Reduce congestion Improve operational efficiency
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Alternative Fuels



2030
 Source: US DOE, EIA, Annual Energy Outlook (AEO) 2008



2010 | **2012** Reduce emissions by 10%, to 2005 levels | **2020** Reduce below 2005 levels by 20% | **2030** Reduce below 2005 levels by 40%

Target Year

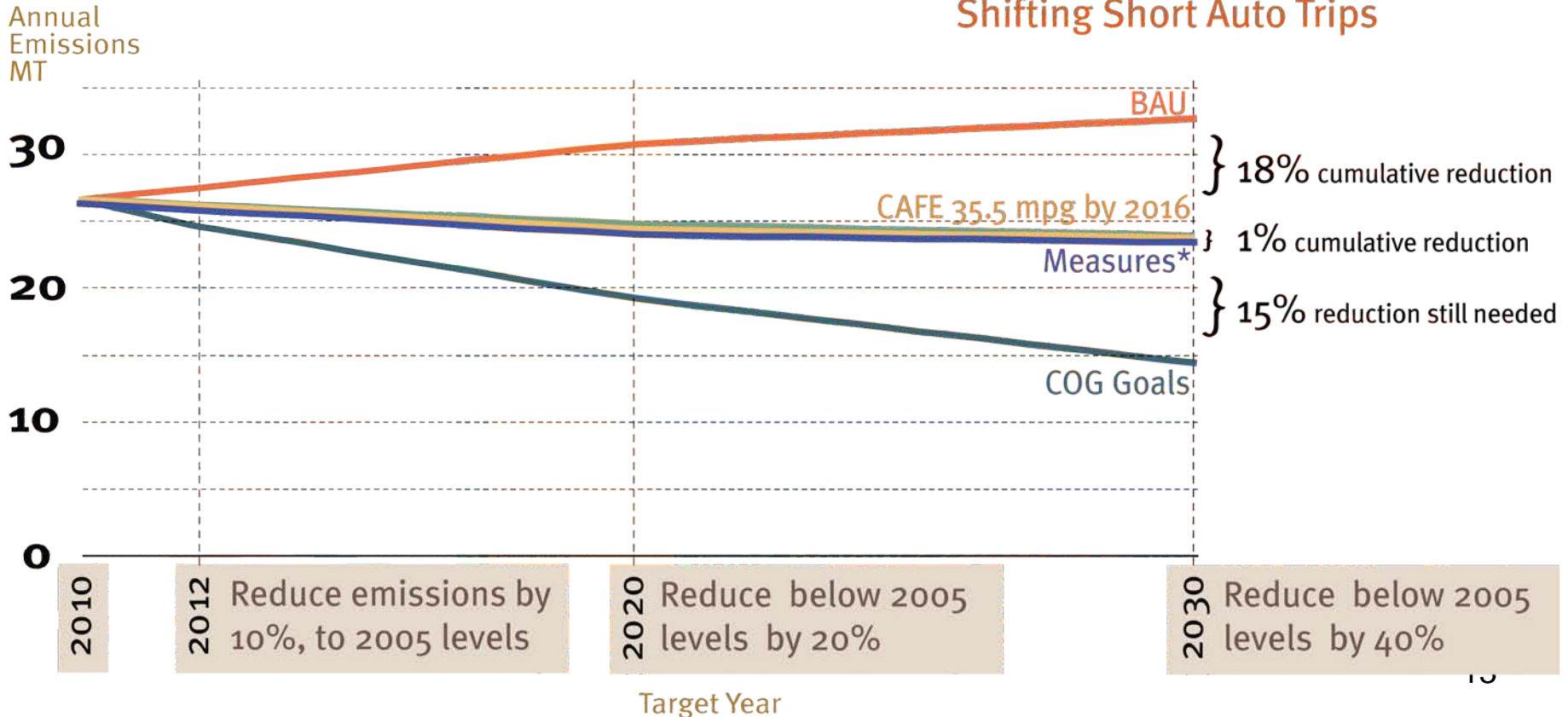
Achieving the Goal

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Travel Efficiency Measures Analyzed to Date

SmartBikes, BikeStations,
TPB Bike/Ped Plan, Carpool Incentive,
Shifting Short Auto Trips



* Measures are shown as additive, though the individual measures may have overlapping benefits

Other Measures to be Analyzed

Measure	Description	Reduction (tons)
Increase Fuel Efficiency Beyond CAFE Requirements	Extending CAFE requirements past 2020 Extending CAFE to heavy trucks Incentive programs for fuel efficient vehicles	
Regional Green Fleet Policy	Examine a green fleet policy for public and private fleets, transit, and others possibly based on other regional models	
Expand existing commuter options	Expand existing programs: commuter connections, guaranteed ride home, telework, park & ride lots and bike/ped access	
Use of financial incentives	Examine tolling, parking pricing, congestion pricing	
Land use and transit changes	Analyze GHG benefits of CLRP Aspirations Scenario	

Next Steps

Complete ongoing analysis of transportation GHG reduction measures

Conduct cost-effectiveness and cost benefit analyses

- TIGER grants guidance, \$33/ton of CO₂
- Cost-benefit analysis allows capture of:
 - Multiple project benefits (e.g. time savings + CO₂ + others)
 - Changing \$/ton of CO₂ over time

Transportation Planning and Climate Change in the Central Puget Sound Region

TRB Webinar: State and Local Government
Responses to Climate Change

October 6, 2009



Outline of Presentation

Setting the stage

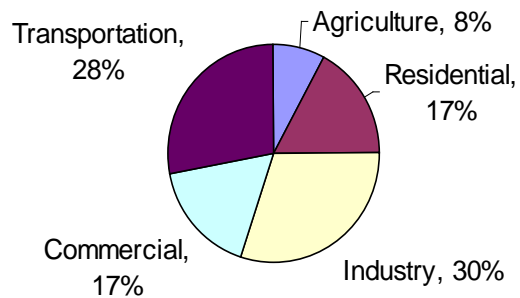
- Washington State, Local Government Actions

PSRC

- Who we are, what we do
- How are we incorporating climate change into our planning processes
- Technical work, policy issues

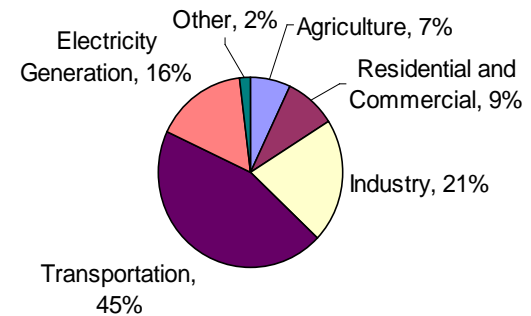
Washington State and Climate Change

US Greenhouse Gas Emissions by Sector, 2004



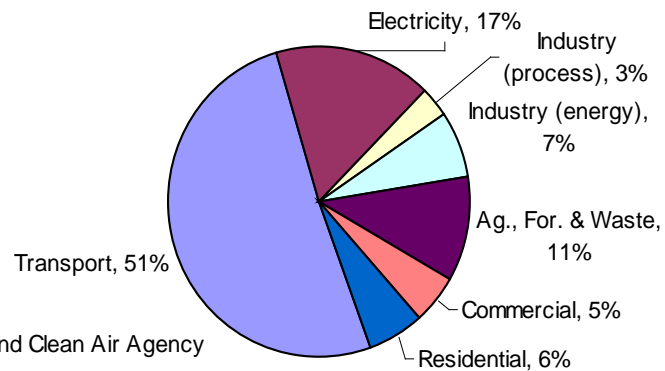
Source: Pew Center on Global Climate Change

Washington State Greenhouse Gas Emissions by Sector, 2004



Source: WA Dept. of Community, Trade and Economic Development

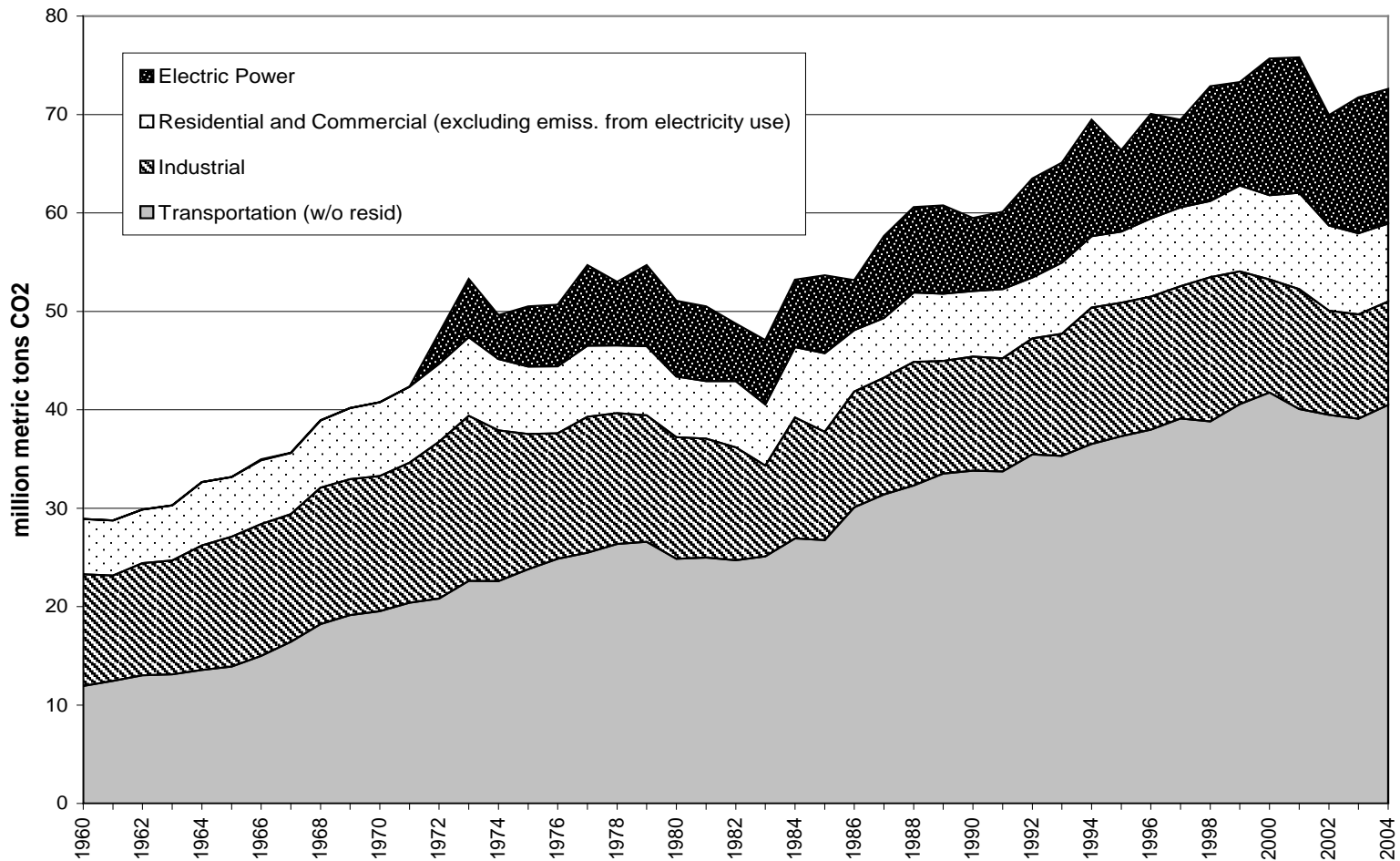
2002 Greenhouse Gas Emissions for the Puget Sound Region



Source: Puget Sound Clean Air Agency

Washington State and Climate Change

Cumulative Energy-Related CO₂ Emissions by Sector in Washington State (CTED)



Washington State and Climate Change

Greenhouse gas emission reduction goals:

- ***To 1990 levels by 2020***
- ***25% below 1990 levels by 2035***
- ***50% below 1990 levels by 2050***

Climate Change Framework:

- Emissions monitoring and reporting system
- Regional multisector market-based system
- Green Economy Jobs Growth Initiative
- ***Statewide vehicle miles traveled reduction benchmarks***
 - Using a baseline of 75 billion total statewide VMT in 2020, less VMT from trucks over 10,000 lbs.:
 - By 2020, decrease annual per capita VMT by 18%
 - By 2035, decrease annual per capita VMT by 30%
 - By 2050, decrease annual per capita VMT by 50%

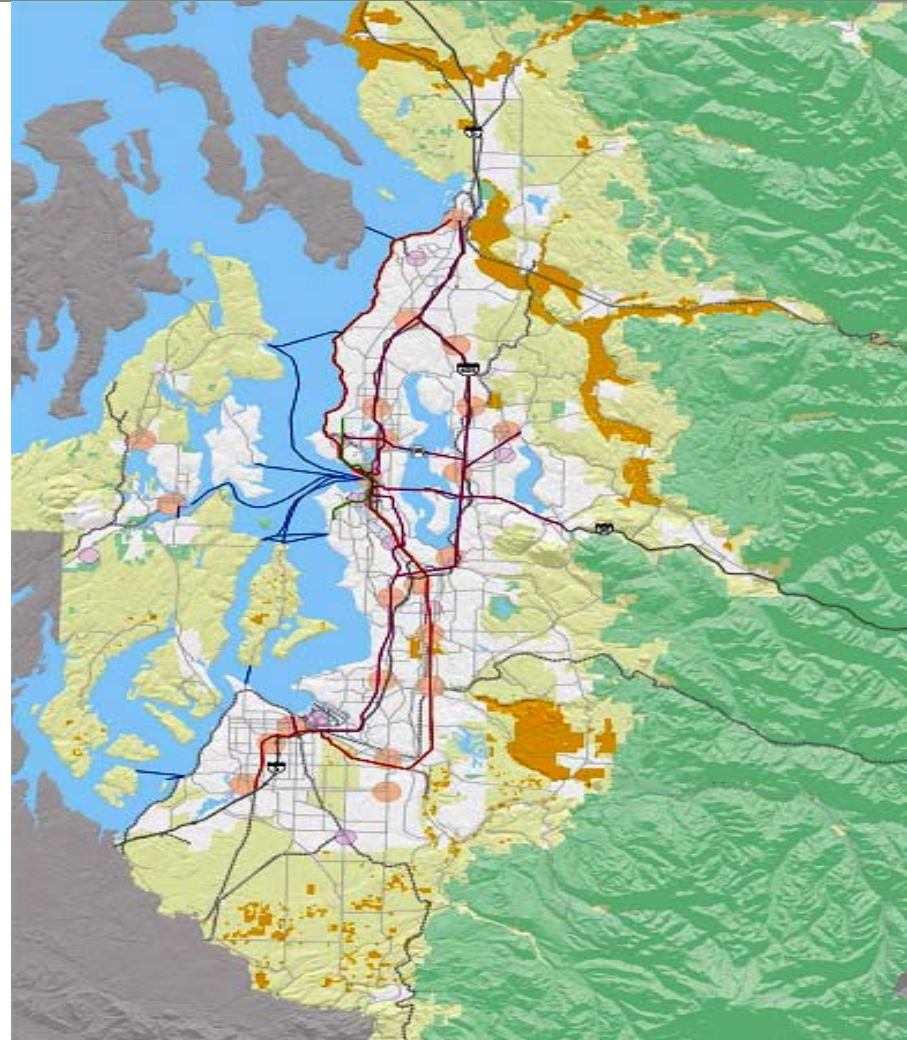
Washington State and Climate Change

- Numerous other state actions, including vehicle electrification and biofuel goals, clean car standards, clean technologies, renewable energy goals, etc.
- December 2008 Climate Action Team report to the Governor and Legislature:
 - “Most promising” strategies to reduce GHG emissions
 - Four working groups:
 - Built environment
 - Transportation
 - Beyond waste
 - State Environmental Policy Act
- Local government actions:
 - King County Global Warming Action Plan, climate preparedness guidebook, renewable energy order, environmental reviews
 - Seattle Climate Action Plan, US Mayors Climate Protection Agreement, climate partnership

PSRC Region

Four Counties – King, Kitsap, Pierce, Snohomish

- Major cities include Seattle, Tacoma, Bellevue, Everett, Bremerton
- Approx. 55% of the state's population
- Located between the Cascade and Olympic mountain ranges, bisected by Puget Sound



PSRC: Who We Are

Metropolitan Planning Organization for the Central Puget Sound Region

- 90 Member Agencies/Organizations: counties, cities/towns, ports, transit agencies, tribes, Washington State Department of Transportation, Washington State Transportation Commission
- Transportation, Growth Management, Economic Planning
 - VISION 2040 – regional growth, transportation and economic strategy
 - Destination 2030 – 30-year long-range metropolitan transportation plan
 - Prosperity Partnership – coalition of government, business, labor and community organizations to develop and implement a regional economic strategy

PSRC and Climate Change: VISION 2040

VISION 2040, the regional growth, transportation and economic strategy:

- Adopted April 2008
- Addresses anticipated growth by the year 2040: 1.7 million more people, 1.2 million more jobs
- Environmental Framework (new; includes climate change)
- Regional Growth Strategy – focus growth in urban centers and compact communities
- Multicounty Planning Policies - environment, economy, development patterns, transportation, public services, housing
 - Climate change addressed throughout
 - Goal: The region will reduce its overall production of harmful elements that contribute to climate change
 - Action: Regional Climate Action Plan
- Analysis - CO₂ analysis in EIS, growth alternatives comparisons
 - Broad analysis based on total vehicle miles traveled

PSRC and Climate Change: Transportation 2040

Transportation 2040 and Climate Change

- Update to Destination 2030, scheduled for adoption April 2010
 - DEIS released for public comment through July 31, 2009
 - Preliminary Preferred Alternative analysis September-October 2009
 - Draft Plan October-December 2009
 - FEIS February 2010
 - Final Plan April 2010
- Policy Board direction to consider climate change in the update
- Scoping process identified climate change as a significant issue to be addressed, along with:
 - Land Use
 - Economy
 - Congestion and Mobility
 - Equity and Special Needs Transportation
 - Safety and Health
 - Security
 - Energy and the Environment
 - Preservation of the System
 - Funding
 - Project Prioritization

PSRC and Climate Change: Transportation 2040

Technical Issues:

- VISION 2040: tools capable of simple greenhouse gas analyses, only VMT-based
- Transportation 2040: travel demand modeling improvements plus utilizing draft MOVES model
 - Ability to analyze for speed variations, changes in vehicle/fuel mix, corridor/subarea analyses, analysis of transportation and land use strategies (e.g. pricing, cost of fuel, etc.)
 - More refined greenhouse gas analyses of each alternative
 - Board direction to address the state's greenhouse gas reduction goals and VMT reduction benchmarks as part of the Transportation 2040 alternatives analysis
 - Draft alternative designed to address both
 - Emissions and VMT reported for all alternatives
 - Emissions included in the environmental criterion
 - Research on the potential from improved technologies

PSRC and Climate Change: Transportation 2040

Transportation 2040 Climate Change Analyses:

- Greenhouse gas emissions quantified for each alternative using the draft MOVES model
- Emissions and VMT included as part of the criteria for evaluating results
- Analysis of energy consumption -
 - VISION 2040 policy screen
 - Estimated energy consumption of each alternative from the following: fuel consumption, construction activity and land use development
- Research into the potential emission reduction benefits from technology –
 - Combination of information from the draft MOVES model, as well as “off-line” research into vehicle and fuel technologies
 - Research also needed regarding market penetration rates, ability to accelerate technology improvements

PSRC and Climate Change: Transportation 2040

Policy Issues:

- Transportation 2040 will also need to consider and address the impacts of climate change *to* the transportation system (adaptation):
 - Accelerated pavement deterioration
 - Flooded roadways
 - Bridge damage
 - Increased maintenance
 - Increased stormwater, drainage issues

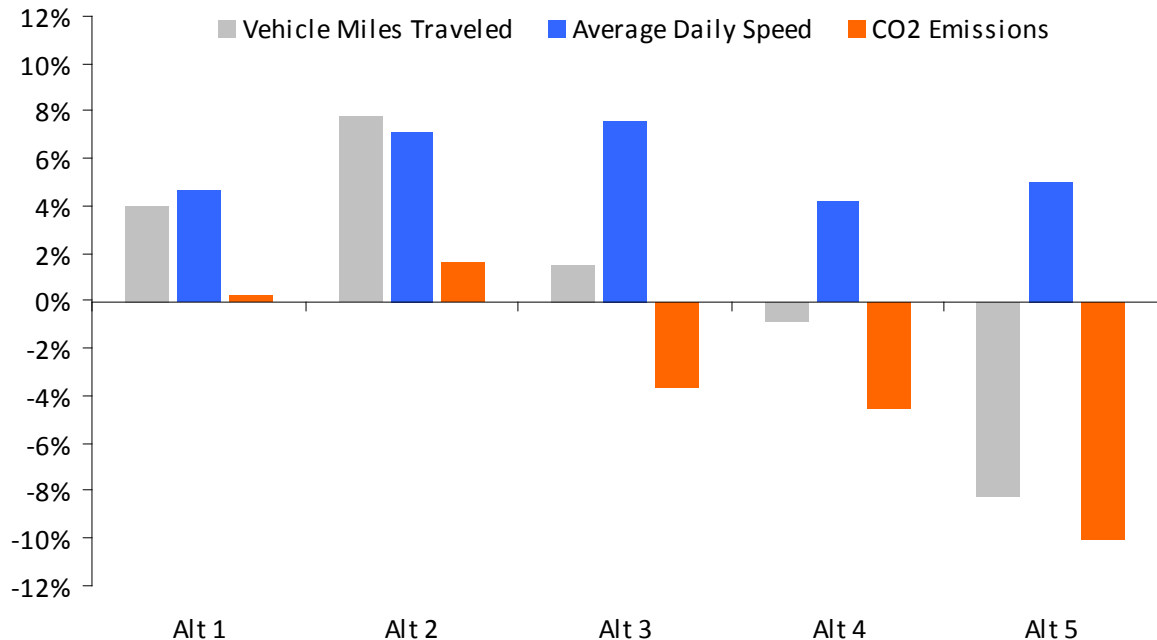
Transportation 2040: DEIS Results

Does reducing congestion reduce greenhouse gas emissions?

Speed and the amount of travel are the key components for the amount of emissions produced – improving the flow of traffic* and reducing vehicle miles will reduce emissions.

** Each pollutant has a specific “speed curve” – the optimal speed for reducing emissions is around 45-50mph*

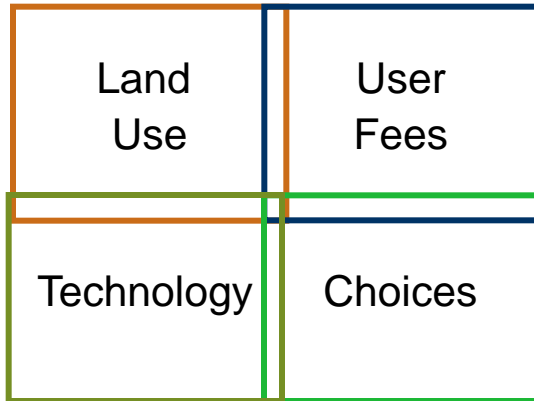
Vehicle Miles Traveled, Speeds and CO2 Emissions
Percent Change from the 2040 Baseline



Person Trips in 2040

Baseline	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
19,150,000	19,176,000	19,191,000	19,170,000	19,169,000	19,147,000

Transportation 2040: 4 Part GHG Strategy



Land Use

Implement VISION 2040

- Jobs Housing Balance (macro)
- Centers, Transit Oriented Development & efficient communities (micro)

User Fees

Implement Roadway Pricing to support VMT reduction and reduce travel delay emissions

Choices

Expand transportation choices that reduce GHG emissions ⁽¹⁾

Technology

Support development of technology to dramatically reduce tail pipe emissions ⁽²⁾

(1) Post plan work item designed to better understand the cost and benefits of strategies

(2) State, local and regional action item-white paper being developed

PSRC and Climate Change: Collaboration

Climate Change Technical Working Group

- EPA, Ecology, WSDOT, Puget Sound Clean Air Agency, King County, Sound Transit, others
- Original objectives:
 - Discuss climate change analysis needs
 - Coordinate regional/state climate change activities
 - Consistency in methodologies, talking points
- Current objectives:
 - Assist PSRC as we incorporated climate change into Transportation 2040
 - Provide technical assistance to local agencies for project-level greenhouse gas analyses
 - June 2009 Draft Project-Level Transportation GHG Evaluation Protocol
 - Ensure regional consistency

Contacts and Information

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Documenting Climate Change Considerations in the National Environmental Policy Act Process for Transportation Projects in Colorado, Utah and Other States

October 6, 2009

Greenhouse Gas Analysis at the Project Level

- **No current Federal requirement under NEPA or planning law to calculate greenhouse gas impacts of projects**
- **Analyzing at the planning level is appropriate**
 - Consistent with current planning factors
 - Can capture synergistic effects of multiple projects
 - Can incorporate by reference in NEPA documents
- **But analyzing at a project level is not likely to be meaningful**
 - Small changes in emissions relative to global totals—evaluating climate impacts of these small changes not practical

Why Might GHG Analysis be Completed at the Project Level?

- **State requirement to do so**
- **Response to public or reviewing agency comments**
- **GHG reduction is part of the Purpose and Need for the project, or is one of the advertised benefits**
- **FHWA is providing technical assistance to states that are performing GHG analysis as a result of state requirements**

Project-level Analysis: State Provisions (Examples)

- **Required:**
- **New York, Massachusetts, Washington, California**
- **Recommendation in final state Climate Action Plan but not implemented yet:**
- **Florida, Maryland, Minnesota, Montana, Wisconsin**
- **Recommendation included in draft state CAP:**
- **Alaska, Arkansas, Iowa, Kansas, New Jersey, Virginia**

Spectrum of Current Practice in NEPA

- 1) No analysis or discussion
- 2) Boilerplate language, but no analysis
- 3) Semi-quantitative emission approaches
- 4) Quantitative emissions analysis--operational changes only
- 5) Quantitative analysis--operational plus construction emissions

Colorado/Utah “Semi-Quantitative” Approach

- **Developed in early 2008 in consultation with EPA Region 8 (Denver)**
- **Included in Cumulative Effects section of NEPA documents**
- **Background information on:**
 - Climate change
 - Federal efforts
 - State efforts (e.g., from state CAP)

Colorado/Utah “Semi-Quantitative” Approach

- **Table compares**
 - Current global CO₂ emissions
 - Current and future state CO₂ emissions
 - VMT on project corridor versus statewide VMT
- **This approach allows readers to**
 - See state’s share of global emissions, and
 - See project contribution to state emissions
- **Can be used for all projects (project VMT is only variable that changes)**

Colorado/Utah “Semi-Quantitative” Approach

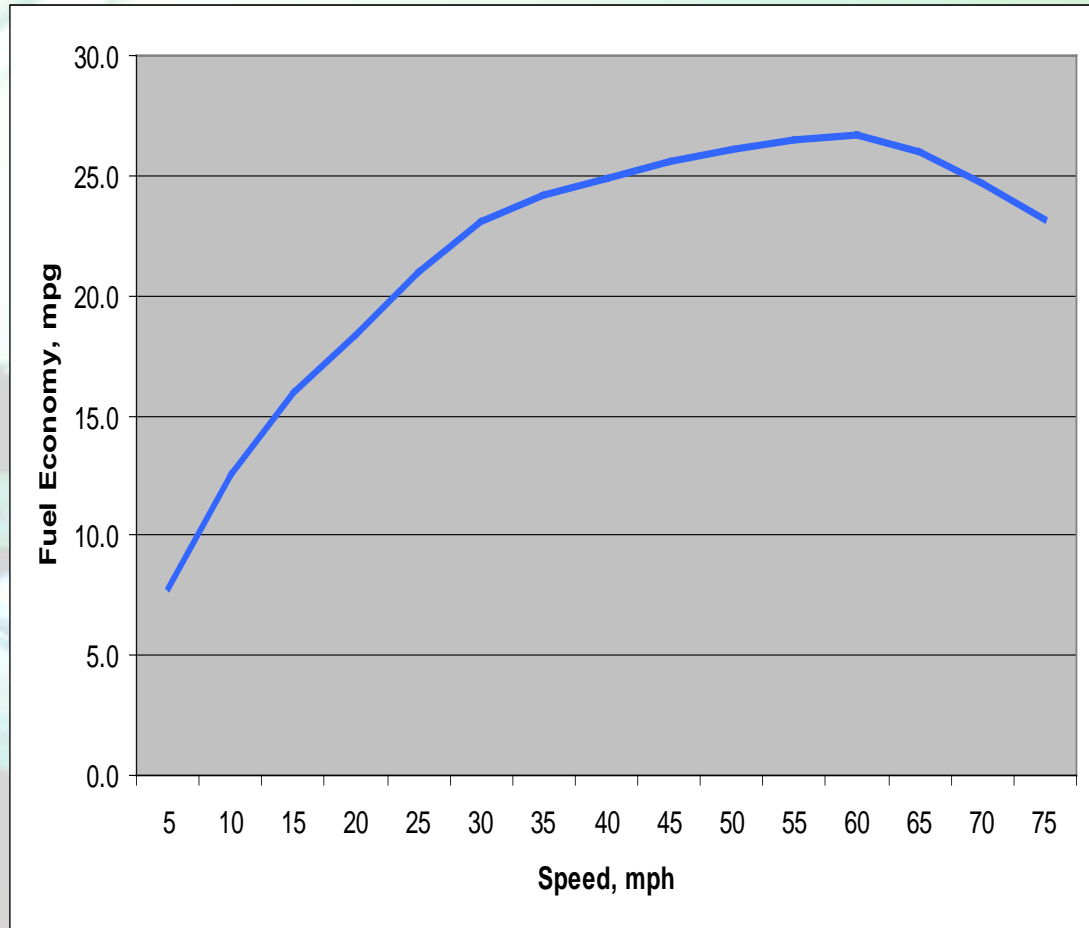
Global CO₂ emissions, 2005, million metric tons (MMT)	Colorado highway CO₂ emissions, 2005, MMT	Projected Colorado 2035 highway CO₂ emissions, MMT	Colorado highway emissions, % of global total (2005)	Project corridor VMT, % of statewide VMT (2005)
27,700	29.9	31.3	0.108%	(user-supplied)

Operational Emissions: Massachusetts

- **GHG analysis required for all projects subject to MEPA (state NEPA law)**
- **Also required to identify measures to avoid, minimize or mitigate emissions, and quantify their impact on emissions**
- **Analysis covers direct CO₂ emissions**
- **Transportation approach: multiply VMT by MOBILE6.2 CO₂ emission factors**

Why Isn't VMT a Good Measure of GHG Emissions?

Fuel consumption (fuel economy) varies with speed, so projects that increase (or decrease) speeds impact energy use even if VMT stays the same



Source: MOVES Demo

Lifecycle: New York

- **Energy and CO₂ analysis required for projects, plans and TIPs**
- **Analysis includes direct (operational) energy and indirect (construction) energy for roadway and rail projects**
 - Build/no-build analysis
 - Analysis years are 2010, 2020 and last year of plan
- **Look-up table/spreadsheet approach used, based on 1980's-era California procedures**

Lifecycle: Washington

- **WSDOT updated the Energy section of its Environmental Procedures Manual earlier this year to include requirements for analysis of GHG emissions from project operation and construction.**
- **Qualitative or quantitative analysis is required, depending on the scope of the project and the availability of analysis tools; see www.wsdot.wa.gov/publications/manuals/fulltext/M31-11/440.pdf**

Key Considerations for Project-Level Analysis

- **Up-to-date emissions rates (MOVES)**
- **Speeds (changes in congestion)**
- **Construction and maintenance emissions; pay-back periods**

Research Needs

- **Energy/GHG impacts of construction and maintenance (NCHRP project underway)**
- **Energy/GHG impacts of project design elements (grade, curve radius, ramp length, ramp metering, roundabouts vs signalized intersections)**
- **Standardized, easy-to-apply methodology for lifecycle analysis**
- **Tools, data and decision framework for adaptation**